What is claimed is:

1. A method for heating and humidifying a reactant gas supply stream for a solid polymer fuel cell, the reactant gas supply stream being directed to a reactant gas inlet port of the fuel cell, and the fuel cell having a reactant gas exhaust stream directed from a reactant gas exhaust port of the fuel cell, the method consisting essentially of:

(a) providing a combined heat and humidity exchanger comprising a supply stream chamber, an exhaust stream chamber, and a water permeable membrane separating the two chambers;

(b) directing the reactant gas supply stream through the supply stream chamber upstream of the fuel cell reactant gas inlet port at a flow rate selected such that the residence to diffusion time ratio, R, for a water molecule in the supply stream chamber is greater than about 0.75; and

(c) directing the reactant gas exhaust stream from the reactant gas exhaust port through the exhaust stream chamber,

whereby water and heat are transferred from the reactant gas exhaust stream to the reactant gas

supply stream across the water permeable membrane.

2. The method of claim 1 wherein the flow rate of the reactant gas supply stream through the supply stream chamber is selected such that the residence to diffusion time ratio, R, for a water molecule in the supply stream chamber is in the range from about 0.75 to 1.5.

3. The method of claim 1 wherein the flow rate of the reactant gas supply stream through the supply stream chamber is selected such that the residence to diffusion time ratio, R, for a water molecule in the supply stream chamber is in the range from about 0.75 to 1.

4. A method for heating and humidifying a reactant gas supply stream for a solid polymer fuel cell, the reactant gas supply stream being directed to a reactant gas inlet port of the fuel cell, and the fuel cell having a reactant gas exhaust stream directed from a reactant gas exhaust port of the fuel cell, the method consisting essentially of:

(a) providing a combined heat and humidity exchanger comprising a supply stream chamber, an exhaust stream chamber, and a water permeable membrane separating the two chambers;

(b) directing the reactant gas supply stream through the supply stream chamber upstream of the fuel cell reactant gas inlet port; and

(c) directing the reactant gas exhaust stream from the reactant gas exhaust port through the exhaust stream chamber at a flow rate selected such that the residence to diffusion time ratio, R, for a water molecule in the exhaust stream chamber is greater than about 0.75,

whereby water and heat are transferred from the reactant gas exhaust stream to the reactant gas supply stream across the water permeable membrane.

5. The method of claim 4 wherein the flow rate of the reactant gas exhaust stream through the exhaust stream chamber is selected such that the residence to diffusion time ratio, R, for a water molecule in the exhaust stream chamber is in the range from about 0.75 to 1.5.

6. The method of claim 4 wherein the flow rate of the reactant gas exhaust stream through the exhaust stream chamber is selected such that the residence to diffusion time ratio, R, for a water molecule in the exhaust stream chamber is in the range from about 0.75 to 1.